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Principles of Index-based Country Level Climate Risk Assessment

A briefing note for the Singapore Green Finance Centre

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Regulations around the world are making it increasingly necessary for boards to become familiar with the concept of climate risk. Across asset classes, such assessments of physical and transition risk are usually at a corporate and transaction level where they can be looked at by sector. However, some risks present themselves more consistently at a regional level; extreme weather events impacting certain areas or policies limited to national boundaries. Therefore it is also necessary to assess these risks at a country level, and a common method to have such a parallel point of reference is to create an index where countries are scored based on their climate risk (or alternatively in two indices for physical and transition risk), and then grouped in quartiles based on the severity. This could then be used to cap regional risk exposure or even overlay on quantitative risk models for sovereign debt, which is especially relevant in recent times as several countries have raised much longer term debt to fund the recovery from COVID-19.

The perspective of country level risk is most established in the form of sovereign credit ratings. Over the last few years, credit rating agencies have increasingly acknowledged the importance of climate change as a risk, but have only just started to integrate it in their core quantitative models due to longer horizons and uncertainties. However, there exist several pieces of literature linking climate risks to their financial impacts. Here, we refer to a seminal paper on *Climate Change and Sovereign Risk* (ADB 2020), in which the authors lay out the transmission channels that connect the two. Note however, that this is used to gain a perspective on index-based risk assessment than to convert risks into financial impacts.

In the following pages, we lay out a framework for understanding country level climate risks, note existing literature including different assessment approaches in industry and point out some common issues. Following the standard taxonomy, the sections are divided into physical and transition risk.

Physical Risk

As we experience the effects of climate change and transition to a more sustainable economy at the same time, several transmission channels will result in financial impact, but three key ones pertain mainly to physical risks. Firstly, the authors of the ADB paper underscore the importance of natural capital for national economic growth and thus **the depletion of natural capital (1)**, which is exacerbated by physical climate risks as a key transmission channel. These risks are divided in two parts: chronic risks that evolve slowly with time such as sea level rise, increasing temperatures, droughts, etc. and acute risks of extreme weather events exacerbated by climate change such as tropical cyclones, floods and heat waves. While there are interlinked effects, they correspond to the two other channels: **the fiscal impact of climate disasters (2)**, where climate change exacerbated extreme weather events result in contingent liabilities for the sovereign such as disaster relief spending or bail-out of state-owned enterprises, and **macroeconomic impacts of climate change (3)**, usually due to sustained impacts such as reduction in crop yield due to higher temperatures. The below table lists the key indicators of these transmission channels.

Depletion of Natural Capital	Fiscal Impacts of Climate Disasters	Macroeconomic Impacts of Climate Change
• Ecological footprint of country • Dependency of economy on ecosystem services	• Projected frequency of extreme weather events • Historical loses from events and contingent liabilities • Availability of disaster funds	• Projected impacts of climate change on economic sectors

Figure 1 – Transmission Channels and key Indicators of physical risks, adapted from ADB 2020

With this framework and list of indicators in view, we look at a few different indices that attempt to assess physical risks at the country level.

- Germanwatch – Global Climate Risk Index: Based on insurance loss data from Munich Re, this index covers a key indicator of historical losses. However, the deterministic nature of the past, especially as it relates to singular high impact events, means that it is not a good measure of what will occur in the future as the frequency and intensity of extreme weather events increase due to climate change. While such indices backed by robust insurance loss data are crucial and should be considered, using measures scaled by population and GDP for the respective losses can help make such data a measure of sensitivity to extreme weather events rather than of past exposure.

- Four Twenty Seven: This climate risk data and market intelligence affiliate of Moody's has conducted an extensive assessment of six different climate hazards and their projected regional impacts at a very high geographic resolution (visualized well by The New York Times). Such analysis of future climate risks are static (unlike indices based on current data), but at the same time avoid the issue of scenario uncertainty due to their relatively short horizon. To be financially relevant, this specific paper measures risks in 2040, for which the impacts of climate change are already 'baked in' due to historic greenhouse gas emissions and delayed physical impacts. Notably, the distribution of risk severity is markedly different in such future projections than that reflected in retrospective insurance loss-based indices.

- Macroeconomic Impact Analysis of Chronic Risks: Another form of static analysis looking at the impacts of future climate change quantify the effects of chronic hazards like heat stress and sea-level rise in terms of GDP. While both transmission channels are important to sovereign risk, extreme weather events usually affect it through the fiscal budget while chronic risks impact the overall economy and thus longer-term macroeconomic growth. Recent studies of this type (like one by the IMF and another published in Nature) are used in several sovereign risk impact analyses.

Other indices like that developed by the European Investment Bank and FTSE Russel also attempt to quantify physical risk at a country level but they go a step further and model the financial impact of the risks. While the constituent factors may be clear, the financial materiality of the risks can be quite different based on the assessing organizations perspective on horizon and use case. The below points lay out three crucial considerations in this regard.

Horizon & Scenario: Typical corporate financial outlooks are short term and even long term horizons don't usually go beyond ten years, while physical risks will only get more severe beyond that. If longer term risks are ignored, the assessment may not correctly incentivize the appropriate mitigation and adaptation actions. A related issue is the physical risk scenario, as continuing GHG emissions result in more severe risks. In this regard however, given the delayed climactic effects we have already 'baked in' due to historical cumulative emissions, most analyses consider a worst case RCP 8.5 scenario (highest warming projection by the IPCC) for impacts up to 2050.

Adaptive Capacity: A significant part of assessing physical risks is the ability of countries to adapt to and recover from climate impacts. This often naturally correlates with countries' incomes per capita, but considering such factors within a climate risk assessment methodology can create issues of endogeneity if used in tandem with existing metrics that also consider similar factors (e.g. sovereign ratings). The methodology used by Moody's Investor Service deals with this by assigning three Issuer Profile Scores to countries that describe their E, S & G risks and a Credit Impact Score that shows how much these factors affect a country's rating. Thus, depending on the organization's use case, it may want to tweak its use of factors considering adaptive capacity in its methodology. Some factors however, may be climate specific and may not correlate with GDP, e.g. early warning systems that can be critical in reducing fatalities.

Static and Dynamic Factors: When creating an index, it is attractive to consider regularly updated data so as to keep it up-to-date. This is possible when considering factors like past disasters, but in climate risk assessment, long term projections of impacts are in the form of academic papers and other studies, which are bound to be static. Therefore, it is important to consider that an assessment of physical climate risk in a 2040+ horizon may indeed not need frequent updating and is bound to use a mix of static and dynamic data sources.

Before creating any physical risk ranking, it is essential for the organization to determine the relevant time horizon and use case for the index. Beyond ensuring the consideration of all transmission channels and indicators, appropriate calls on the inclusion of adaptive capacity will allow the best integration of the ranking into existing processes.

Transition Risk

While the above section discusses the risk posed by the physical effects of climate change, transition risk is caused by our collective move to a decarbonized economy in an effort to avert those effects. Given the necessarily rapid pace of such a transition, it is bound to pose risks to the existing ways of doing business. The two main transmission channels of this kind of risk at the country level are: **the impacts on international trade (1)**, where the exports of

fossil fuel producing nations will drop as global demand reduces, and **the fiscal consequences of climate change mitigation policies (2)**, where policies to decarbonize heavy industry may result in lost revenue for governments. The indicators for both of these channels, as noted by the authors of ABD, 2020 are listed below.

Impacts of Climate Change on International Trade	Fiscal Consequences of Climate Change Mitigation Policies
• Carbon intensity of exports • Share of high risk commodities like fossil fuels in exports • Openness of the economy and export diversification	• Share of government revenues from high risk sectors • Expected fiscal cost of mitigation investment

Figure 2 Transmission Channels and key Indicators of transition risks, adapted from ADB 2020

In the short term, a 2021 report from Moody's suggests, "exposure to carbon transition is specific to hydrocarbon producers". But even within that, fossil fuels differ in their carbon intensities, share of primary energy by region, costs, etc. and as such there is differing international willingness to reduce their use. According to the UN PRI's Inevitable Policy Response 2021 Forecast, there is expected to be "a drop in coal output to 15% of its current level by 2050, to 52% for oil, and to 88% for gas". Any measure of short term transition risk must consider this variation, whereby more coal use for electricity is a risk even as natural gas may be a necessity. As is made clear by the Russia-Ukraine war and resultant geopolitical crisis, continuing dependence on fossil fuels remains a risk for countries around the world and while immediate fires may be put out by alternative sources of oil and gas, long term risk to importers can only be reduced by accelerating the energy transition.

Several good methodologies exist that estimate this risk, including HSBC's annual Fragile Planet publication (2018 version focusses on fossil fuels), Fitch Ratings 2021 spotlight on stranded assets and S&P Ratings' Sovereigns ESG paper. The best practices point to three main fossil fuel indicators to monitor: government rents (% GDP), share of exports (% GDP) and coal as share of electricity (%). However, to consider countries' efforts to change, it is also beneficial to consider two additional factors: the trend in these metrics over time and the country's ability to diversify away from fossil fuels.

Beyond the short term, the estimation of transition risk becomes much more difficult. While physical risk is a result of human actions in an indirect and delayed manner, transition risk reflects their direct consequences. Thus, what we do in the coming years directly determines the degree and timing of the risk. This calls for a much more thorough assessment through the use of scenario analysis, whereby risks are evaluated in the context of several possible transition trajectories. This is an evolving field and is not as deterministic. While an index-based approach cannot consider such variations, so far as the ranking is not an absolute measure but rather that of relative risk, it may still be quite useful. Focussing then on the

costs of decarbonization of the wider economy in the medium to long term, one must consider three key points:

- Carbon responsibility: A straightforward measure of the transition risk a country faces may seem to be its total emissions – the amount it needs to reduce. However, the pace at which a country does so is by no means consistent around the world. The responsibility a country bears for its GHG emissions has been a point of contention in international climate diplomacy and there are several schools of thoughts based on historical responsibility, current emissions, etc. However, a clear difference that is reflected in national commitments is that lesser developed countries have longer horizons for their Net Zero goals. As emissions of a person so far correspond well to their income, a good measure of this is the per capita emissions of countries (CO2e/p).

- Efforts to mitigate emissions: A country's emissions can be divided into component parts using the Kaya identity: Emissions per capita = (Carbon intensity of energy), times the (energy intensity of the economy) and (GDP per capita). So while the latter will grow as the country develops, two main ways of reducing emissions is to increase energy efficiency (use less energy per economic output) and reduce the carbon intensity of energy (use cleaner energy sources). Thus, indicators of energy efficiency and renewable energy, along with trends in the indicators are critical to the index.

- Climate Ambition: Country's stated goals may not be achieved on time, but they are an important indicator of the pace and scale of the transition. With the establishment of the Paris Agreement, the self-reported Nationally Determined Contributions (NDCs) are the best indicator of such goals (WRI).

Several existing indices attempt to quantify the above factors, although not all do so in the context of climate risk. Two important ones are the Climate Change Performance Index (CCPI) and the EIB paper referred to earlier. Lastly, while the transition to a decarbonized economy will pose risks, it will also create some opportunities such as revenue from the development and manufacturing of clean energy technologies and the extraction of minerals used in them, which should be considered as they may counteract some of the transition risks.

In this briefing note we have laid out the overarching principles one should keep in mind when making such an index. Yet any organization undertaking such a project must first determine its priorities of use case and horizon of assessment to form its own view on country level climate risks. As the field of climate risk assessment develops, so will their integration into traditional quantitative models of risk assessment. But at a time when awareness of the importance of these risks and associated financial impacts is increasingly relevant, a separate country level index can go a long way. We encourage anyone interested in developing such an index to explore the resources linked to above, and please contact us for more information.